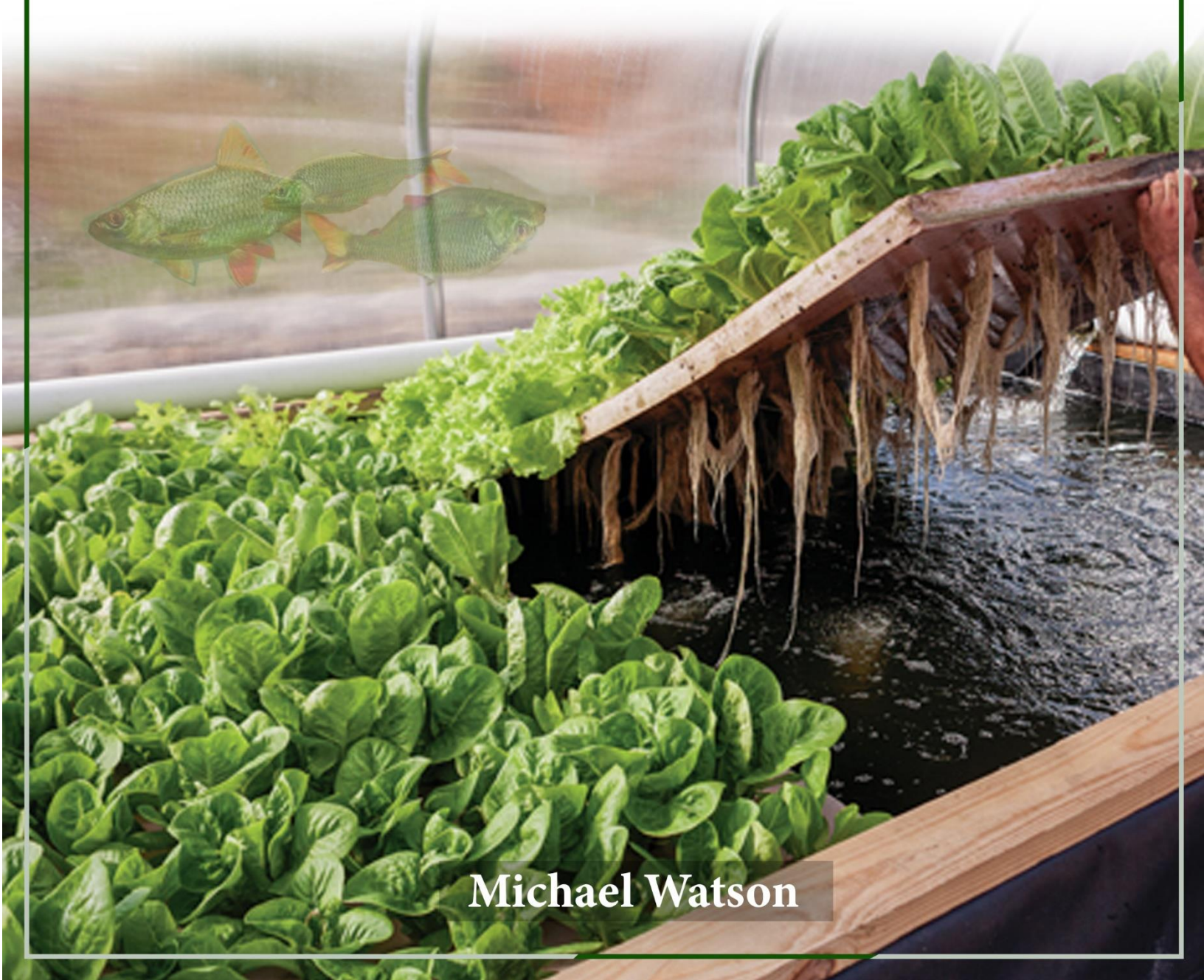
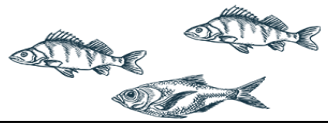
With Illustrations and Step by Step Instructions

The Aquaponic Gardner



Michael Watson

HOW TO GROW YOUR OWN AQUAPONICS SYSTEM

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INTRODUCTION TO AQUAPONICS

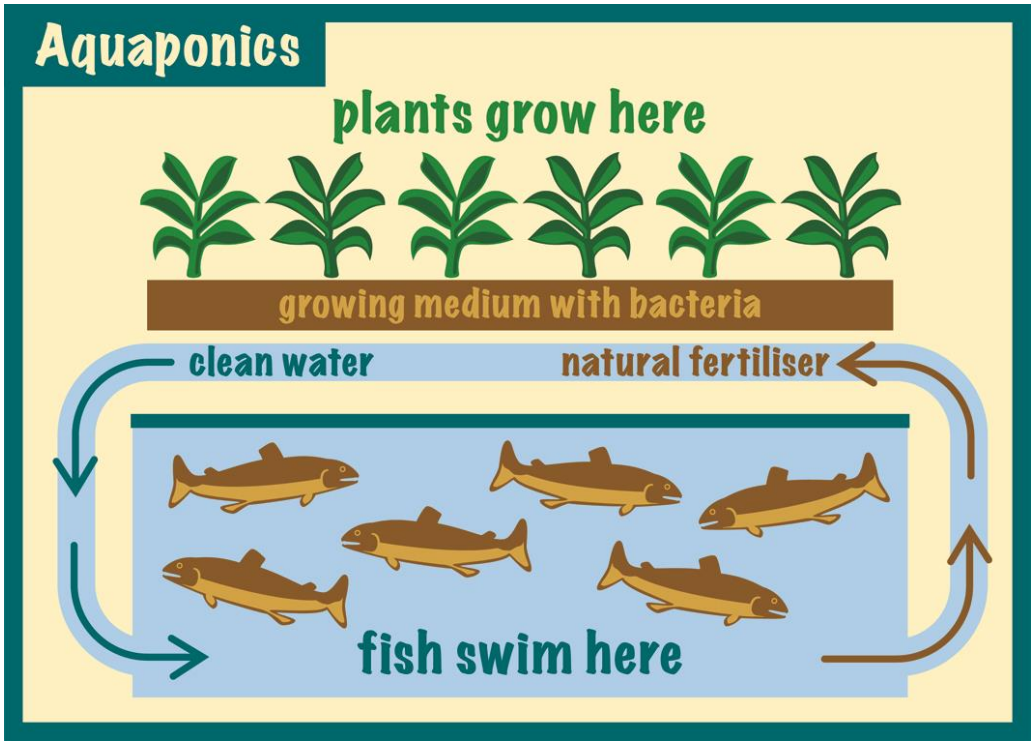


Figure 1: Aquaponics System

The word Aquaponics is typically used to describe an aquaculture system in which both fish and plants are raised and harvested, in a co-dependent environment. Fish waste is an ideal fertilizer for many edible plants, and fish food is exponentially cheaper than plant fertilizer.

A typical Aquaponics system is comprised of three major sub-systems: The Water System, the Plant system, and the Fish system. These three sub-systems work together to create a loop of self-supporting life that requires minimal input or investment to sustain. When setup strategically and cared for properly, this system can provide a steady food supply of both plants and fish.

Hydroponics is a word that often comes up when discussing Aquaponics. A Hydroponic system is composed of plants only. It is also a system in which plants are raised and harvested, but it requires the application of either natural or chemical food and fertilizers. When designed correctly, Aquaponics is generally accepted as a superior alternative to Hydroponics.

While requiring slightly more setup and initial effort, it allows for a more diverse harvest (both Fish and Plants) and is more affordable to maintain. With the excellent plant fertilizer produced from fish waste, maintaining an aquaponics system requires only fish food and general care. Overall it is a system that can provide a much greater return on investment than Hydroponics.

Developing a personal Aquaponics system can be both a fun hobby and a practical way to create an independent food source. If you have a desire to become self-sufficient in providing food to eat, Aquaponics is a great place to start.

When discussing Aquaponics, one important concept to consider is Life Cycle completion time. The phrase "Life Cycle" refers to the complete organic process of a typical Aquaponics system. An example of a typical Life Cycle is shown in figure 1 below.

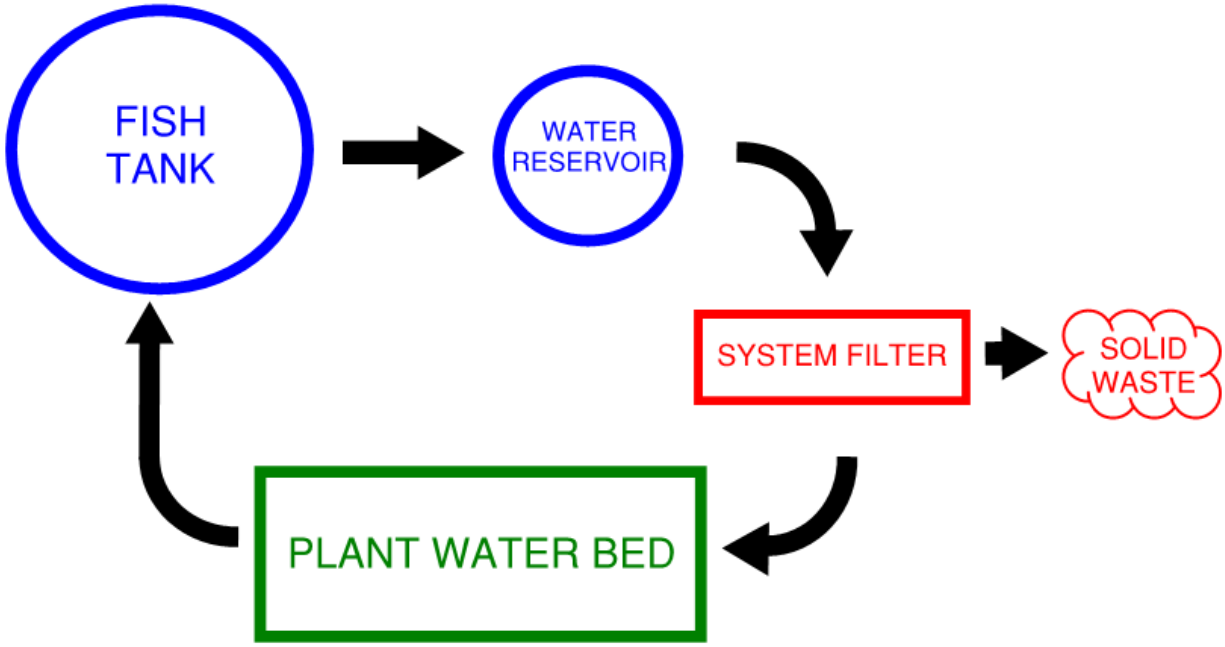


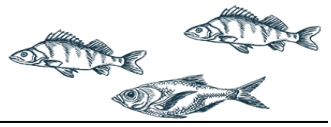
Figure 2: Typical Aquaponics Life Cycle

The completion time of this Life Cycle depends on a number of factors and will determine the frequency and volume of the harvest that can be achieved. How to optimize this life cycle for one's specific situation is discussed further in this guide.

Aquaponics is efficient not only with respect to plant food and nutrients, but also with respect to water use. Traditional gardening typically requires the repeated application of large amounts of water to supplement any rainfall. The water in an Aquaponics system is added one time, and then is repeatedly used by the Fish System and cleaned by the Plant System in an efficient, closed-loop process.

Aquaponics is also a system over which one has a large amount of control. While very dependent on the temperatures and climates present, an Aquaponics system is typically very condensed, which allows for easy control and manipulation of the system components, as needed.

Ultimately, this guide has been written with the goal of bringing this great concept of Aquaponics to a practical level that can be implemented in one's own back yard. The following section gives a brief but complete overview of what is included in this guide.



AQUAPONICS GUIDE OVERVIEW

The purpose of this guide is to provide all of the information needed to build a healthy, successful Aquaponics system. It is suggested that one first reads through this guide entirely before beginning to build an Aquaponics system. Doing this will provide a better overall view of the complete system and will help inform some of the initial decisions that need to be made about size and location.

As mentioned previously, a typical Aquaponics system is comprised of three major sub-systems. Each of these three systems is discussed in-depth in this guide, along with the initial support structure and the keys to starting and maintaining the completed system.

The support structure is the part of the Aquaponics system that can vary the most. There is a specific range of plant types to select from, and a specific list of fish species that would be best for the Aquaponics system, but there is an almost unlimited amount of options when selecting a support structure and overall system layout.

Whether it will be an Indoor or Outdoor system, a 2-fish or 20-fish system, and a parallel or stacked system are just a few of the considerations that must be made. The support structure sections in this guide will provide all of the information needed to help in determining which type of support structure will be best for one's specific situation. These sections will also provide setup instructions for a variety of different support structures.

Sections on the preparation, maintenance, and cycling of the Water system are included in this guide. These sections will give the reader all of the information, instructions, and tips needed to setup this portion of the Aquaponics system. Though the water is not one of the products that can be harvested, it is still a critical part of the system. The quality and health of the water are what both the fish and plan systems depend on for optimal success. Depending on the type of support structure selected, different considerations must be made for the water system. The type of water used in the initial setup of the system is also very important.

Sections on the selection, support, nutrition, and harvesting of the Plant system are also included. Like the water sections, these sections will provide all of the information and instructions needed to develop the Plant system portion of one's very own Aquaponics system. The plants will rely on the Fish waste for food and fertilization, so ensuring a good match between plant type and fish species is key. It is also important to consider the

desired life-cycle completion time of one's specific Aquaponics system, and to select plants that grow at a rate that compliments this completion time.

Also included are sections on the selection, health, life-cycle, and harvesting of the Fish system. The fish system can be the most fun to plan for but can also be the most difficult to setup. It is very important to introduce the fish to the system as a final component, and to take steps to ensure they adjust well to the environment that has been created. These sections of this guide will provide all of the information and instructions needed to ensure the correct fish are selected and this transition goes smoothly.

Finally, separate sections on starting and maintaining the Aquaponics system are included in this guide. Information and instructions are included for the first week of running the system, the first harvest, and the first deep-clean. Even if an Aquaponics system has all of the correct components, if it is not started correctly it will quickly deteriorate. This guide will provide the information needed to ensure the Aquaponics system gets started correctly and maintains healthy life cycles. Information and instructions on common issues and preventative maintenance items are also included in this guide.


THE STRUCTURE

Choosing A Location

The most significant initial decision that must be made is whether this will be an indoor or outdoor system. Both are viable options, and both have desirable and undesirable factors.

An indoor system will allow for easy access when feeding the fish, maintaining the system, and harvesting. It will also ensure a consistent climate, giving a wider range of options for fish species selection.

If one enjoys looking at an aquaponics system or sharing it with visiting guests, this could also be an added bonus. Some undesirable factors in an indoor system may include any odors from the system, any potential mess from spilled water, and limited overall total size.

Depending on one's specific system an outdoor system will typically allow for a much larger overall total size of system. Locating one's system outdoors may result in limited selection of fish species, due to fluctuating temperatures. It may even result in having to shut down the system when the weather gets too cold to maintain fish and plant life. If one lives in a warmer climate, these issues may not apply.

There are additional factors to consider when choosing a location, besides indoor or outdoor. The plant system will require as much sunlight as possible. The more sunlight they can be exposed to, the more the growth of the plants, and ultimately the whole system life-cycle completion time, will be accelerated. However, the more sunlight the water system is exposed to, the more undesirable algae and bacteria will develop in the system.

If a classic parallel system is selected, it will be important to choose a location that has both sunny and shaded areas close to each other. Alternatively, a fully sunny area can be selected and a shade and dark for the water system can be constructed.

If a stacked system is selected, this will not be as much of an issue. Figure 2 below shows a schematic example of a stacked system.

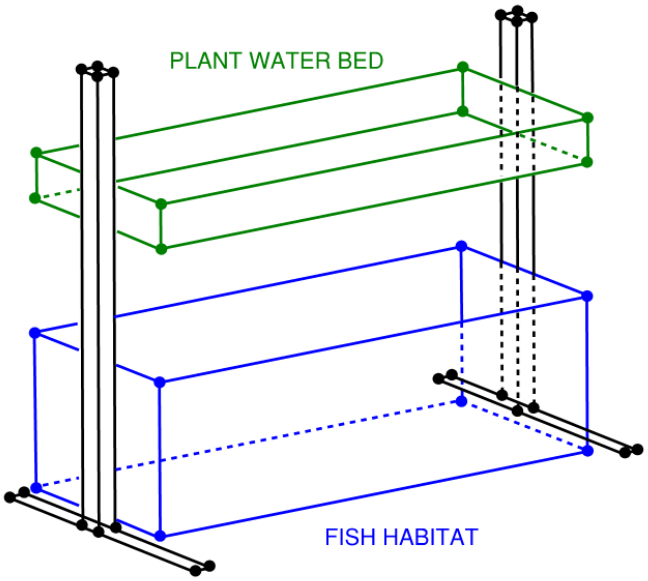


Figure 3: Stacked System Schematic

The classic parallel system is much more common, but in rare circumstances one may have materials already available that would perfectly suit a stacked system. Alternatively, a new exoskeleton frame could be constructed to accommodate a stacked system. As shown, a stacked system exposes the plants to direct sunlight, while providing shade for both the fish habitat location and the water system. While this stacked system requires more significant building and development, it does create a structure that is both sunlight-efficient and space efficient.

Finally, it needs to be determined whether or not the system will be located near a power source. A pump is needed to circulate the water throughout the system and carry the nutrients from the fish habitat location to the plant roots. There are a variety of pumps that can be selected, from solar-powered pumps to standard plug-in pumps to manual pumps. The "Water System" section of this guide gives a pump solution for every location, but it is important to consider all of the options before selecting a final location.

Building the Support System

Construction of the support system will include construction of each of the following main components

- *Fish Habitat*
- *Plant Water Bed*
- *Water Reservoir*

The first step in building each of these components is determining the desired overall scale of the complete Aquaponics system. For systems with 2 – 10 fish, there are a number of simple, pre-made containers that will work for each of the components, that are readily available and fairly affordable. For systems with 10 – 20+ fish, there are custom construction options for each component, based on the specific component needs. Each of these components is discussed in more detail below, with solution options for both small scale and large-scale systems.

The main factor when constructing the fish habitat is volume. The overall shape of the container is not as critical, as the fish can occupy varying depths of water. As a general rule, **1 gallon** of water is required for each **1 pound of fish**, in order to maintain a healthy environment. This translates to approximately **10 gallons** of water for each **8"-10" fish** present. Keep in mind that the sizing of the tank should be based on the final size of the fish before harvesting, not the initial size. The purpose of an Aquaponics system is to grow both the fish and the plants. For a small system, one affordable and easily accessible option is a 20-gallon or 30-gallon clear plastic tote, like the one shown in figure 3 below.

Figure 4: Example 30-gallon clear plastic tote

One of these totes could be large enough for 2 – 3 fish, or two of these totes could be used side-by-side in a system large enough for up to 6 fish.

For a medium-size system, another pre-made option for the fish habitat is traditional 55-gallon plastic barrels, like the one shown in figure 4 below.

Figure 5: Example 55-gallon plastic barrel

Two of these barrels would provide enough space for about 10 or 11 fish, depending on the size and species selected. Fish size and species selection is discussed further in the "Fish System" section of this guide.

For systems with over 10 fish, the most cost-effective option may be to construct a simple water-tight structure using a wooden frame and an industrial waterproof liner. Another option for a large system would be any large pre-made watertight container. As long as it is clean, smooth, and watertight, it may be a viable habitat for fish. Purchasing a container this large may be more expensive and not a better option than constructing one as noted previously. But if one has a container like this already present and not being used, it may be perfect for this Aquaponics system.

The main factor to consider when constructing the Plant Water Bed is surface area. The best container for the plant system will be a shallow container, to maximize the surface area while minimizing the water depth. The Plant Water Bed is actually comprised of 2 pieces – the flood table and the plant support. When selecting a flood table, once again a simple pre-made container may be the simplest and most affordable option. Figure 5 below shows an example of a shallow container that would work well.

Figure 6: Example Flood Table container

It is important to make sure that the flood table does not have any holes in the bottom. 2 holes will be added to the side of the flood table – one at each end, for the water to flow in/out of. This is covered in the construction steps below. But no holes should be added to the bottom, and the container should be able to hold water without leaking.

Alternatively, if one already has a large shallow container available that is capable of holding water, it may be well suited for the Aquaponics system Flood Table. The plant supports component of the Plant Water Bed can be created in a variety of ways, out of a variety of materials. A straight-forward option would be to place dowels across the flood table horizontally in both directions, to create a checkered surface as depicted in Figure 6 below. Another option would be to secure twine or thin rope across the container in the same fashion.

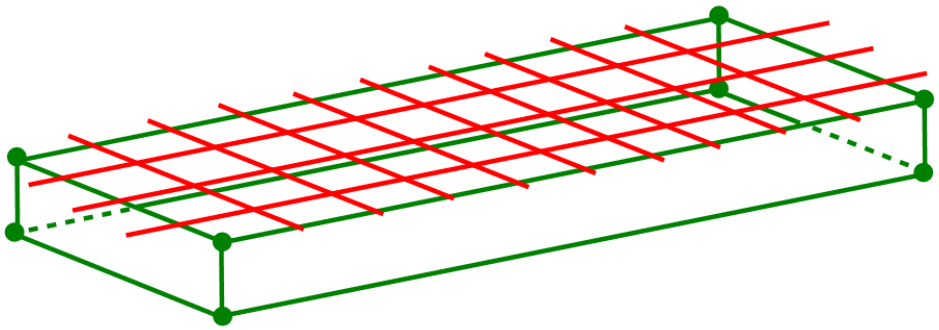


Figure 7: Plant Supports layout schematic

Selecting a large plastic or metal grate such as the one shown in Figure 7 below and placing it on top of the flood table would be an option as well. Ultimately, the goal is simply to have a structure capable of supporting the plant system. Each plant should be held upright, so that the roots can draw nutrients from the water, but the leaves to be harvested remain above water and the entire plant is not submerged in the water.

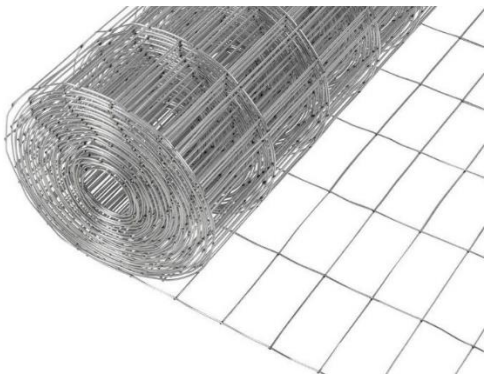


Figure 8: Alternative type of Plant Support

The Water Reservoir is the most flexible of the three components. The purpose of this reservoir is to contain the excess water that is to be cycled. This reservoir will allow for a "buffer" in the water level of the system. One can monitor the water level and add water when needed without disrupting the flow of the system. It also allows for an added filtering stage.

The volume of this reservoir should be approximately half of the volume of the rest of the Aquaponics system. Note that the Fish Habitat will be almost completely full, and the Plant Water Bed will be approximately half-full. An example is listed below.

- 30-gallon Fish Habitat (full)
- 12-gallon Plant Water Bed (half-full)
- **18-gallon Water Reservoir is needed (half of 30 plus 6)**

This Water Reservoir can be any shape or material. The only requirements are that it be watertight, and have at least one point of visibility, so one can monitor the water level and add water as needed.

Once the Fish Habitat, Plant Water Bed, and Water Reservoir are selected, construction of the support structure can begin.

Step 1 (Planning the Support Structure Layout)

Locate the Fish Habitat, Plant Water Bed, and Water Reservoir in the selected area of the Aquaponics system. Think through what layout will me most convenient for this specific system and space.

Arrange the three main components approximately in the formation shown in figure 1 of this guide, but do not anchor anything to the ground yet. The components will need to be moved around when attaching the hose sections and installing the pump.

Step 2 (Planning the required hose sections)

This step requires sections of 1/2" diameter flexible hose. This hose can be found at any local hardware store. An example of the hose needed is shown in Figure 8 below.


Figure 9: 1/2" Flexible Hose

Hose will be needed to make the following connections.

- Water Reservoir to Water Pump
- Water Pump to Plant Water Bed
- Plant Water Bed to Fish Habitat
- Fish Habitat to Water Reservoir

As mentioned above, the 3 main components of the system should be arranged so as to minimize these connection distances as much as possible. An example schematic of the Aquaponics system is shown in Figure 9 below. Note that the filter is not shown in the schematic below, as it is contained in the Plant Water Bed structure.

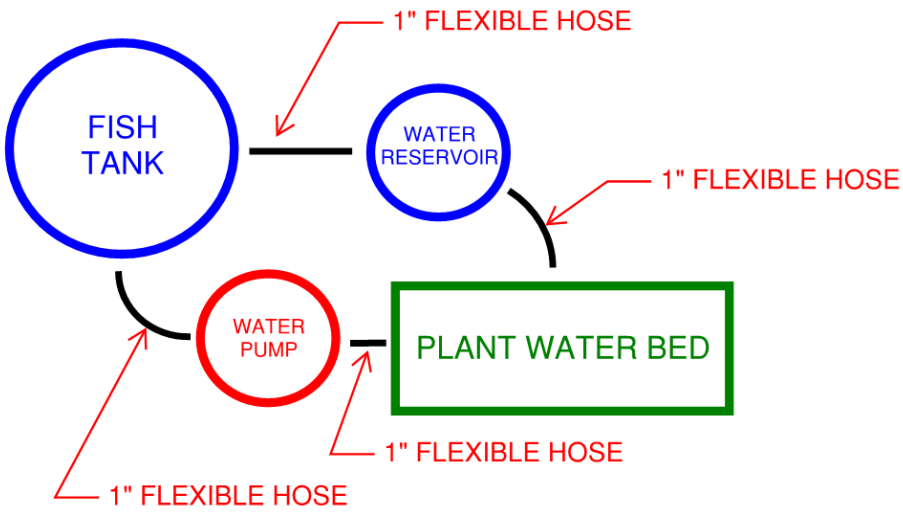


Figure 10: System Layout schematic example

Step 3 (Attaching the hose sections)

Once the final system layout has been confirmed, and sections of hose have been cut to the appropriate length, the hose sections can be attached to each of the three system components, and to the water pump. Attaching the hose to the components will require drilling 1/2" diameter holes and utilizing 1/2" "Uniseal" fittings like the one shown in Figure 10 below. Alternatively, a bulkhead type fitting could be used, but a Uniseal fitting is a much simpler option. This attachment can be found at any local hardware store.

Figure 11: Uniseal Fitting

For each of the three system components, two 1/2" holes should be drilled for the water inlet and outlet. The location of these holes will depend on the specific system layout, but they should be as far away from each other as possible, in order to ensure even flow and distribution.

The centerline of each 1/2" **inlet** hole should be located 1-1/4" from the bottom of the component. The centerline of each 1/2" **outlet** hole should be located 1-1/4" from the top of the component. The only exception to this rule is the outlet point of the Water Reservoir.

Depending on the shape of reservoir selected, the required location of the outlet point will vary.

The reservoir should be kept approximately half full at all times. The centerline of the 1/2" outlet should be located approximately 3" below the waterline, i.e. 3" below the halfway point of the Water Reservoir component selected.

Once attached, the (Hose - Uniseal fitting – Tank) setup should look similar to the schematic shown in Figure 11 below. This schematic is provided directly from the manufacturer as an aid in understanding the concept of the Uniseal fitting. The Uniseal fitting essentially provides the same end result that a bulkhead type fitting would provide, but in a much simpler fashion.

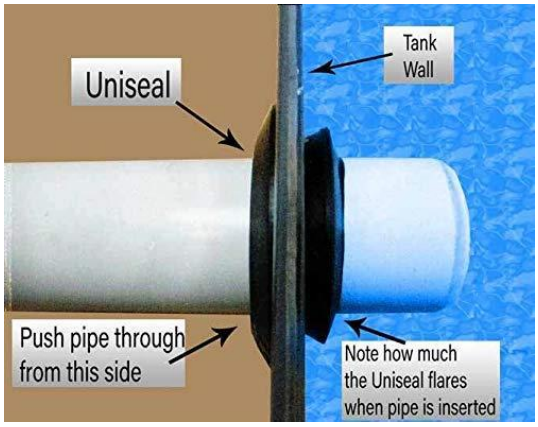


Figure 12: Uniseal complete schematic

The hose should be attached to the water pump inlet and outlet connections in accordance with the pump manufacturer's instructions. The pump sizing and selection process is discussed in more detail in the "Water System Structure Options" section below.

Step 4 (Anchoring the Components)

Once the component layout is finalized and the hose sections have been attached, the system should be anchored for stability. The anchoring process will vary significantly based on one's specific system location.

The surface type, size, and height will all contribute to the type of anchors that can be used. Ultimately, the goal is to secure and stabilize each of the 3 main components, to prevent issues from developing down the road.

Step 5 (Final Inspection, Water Test)

Once construction of the Support System has been completed, the final inspection and Water Test can begin. The "Water System Structure Options" section below gives more

in-depth information on the specific requirements of the water system and on water preparation and maintenance.

Water should be added to the Plant System structure slowly, so that the water flows all the way through the system into the Water Reservoir.

Once the Water Reservoir is half full, completely covering the water outlet, the Water Pump can be turned on. The Water Pump should carry the water up to the Plant Water Bed inlet. From there the water should continue to flow out the hose connection point to the Fish Habitat. As long as the Fish Habitat is filled with water up to the hose connection point, water should flow back into the Water Reservoir.

If at any point in this process the water is not flowing as desired, the height or slope of each system component should be adjusted as needed.

Take care when adjusting the system, as the components can be quite heavy once full of water. Usually only slight adjustments to height or slope are needed to resolve flow issues. Make any changes slowly, one small adjustment at a time.

Once the system is circulating water to all 3 system components, take a close look at each hose connection point to ensure there are no water leaks present. Once this is completed and the system is running smoothly, the Support System is complete.

Water System Structure Options

The Water System is the structure that will probably take the most fine-tuning, in order to ensure smooth and complete water flow. Selecting components to hold the water following the directions above will not be too complicated.

The difficult part is implementing the water pump, hoses, and hose connections. While this process may be the most time-consuming, it is important not to rush through it. Constructing a sound Water System structure now will help decrease the amount of maintenance required down the road.

Step 1 (Determining Pump Size)

The size of pump required will depend both on the total size of the Aquaponics system and on the change in elevation present in the specific layout. The table below lists a few different recommended pumps for each size of Aquaponics system.

	Standard	Solar Powered
Small System (40 – 60 gallons), Small Elevation change (1-2 feet).	SEAFLO SFDP1-030-045-33	Aquatec 5503-AEE-B656
Small System (40 – 60 gallons), Large Elevation change (2-4 feet).	SEAFLO 42-Series Diaphragm Pump	Aquatec 5503-AEE-B656
Medium System (60 – 120 gallons), Small Elevation change (1-2 feet).	SEAFLO 42-Series Diaphragm Pump	Dankoff Solar Flowlight Booster Pump
Medium System (60 – 120 gallons), Large Elevation change (2-4 feet).	SEAFLO 52-Series Diaphragm Pump	Dankoff Solar Flowlight Booster Pump

In most cases, a standard pump that can be plugged in to a typical 120-volt outlet is preferred. A Solar Powered pump will be much more expensive, but may be required if there is no electricity available at the location selected for one's Aquaponics system. Additionally, there are some submersible pump options that may be considered. Submerged pumps are more difficult to monitor and are not recommended for an Aquaponics system, but may be considered if desired. An example of the technical details and overall dimensions provided by the manufacturer for one of the pumps is shown in Figure 12 below.

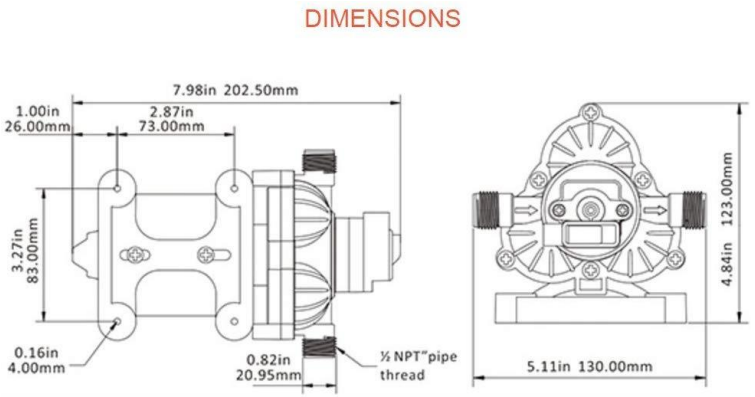


Figure 13: SEAFLO SFDP1-030-045-33 model information

Step 2 (Installing the Pump)

It is important to follow the manufacturer's instructions closely when setting up and installing the water pump. Depending on the pump selected, the pump may need to be anchored securely. Most water pumps create at least some amount of vibration, and it is important that the pump stays in position. Once the pump is setup and secured, follow the instructions from Step 5 in the previous section to cycle water through the system for the first time.

Protective Covering

The construction of a protective covering is not difficult, but it is essential. Of all the possible things that could negatively impact an Aquaponics system, direct sunlight on the water is the worst.

Nothing will kill both the Plant System and the Fish System faster than algae and bacteria growing in the water. If either the Fish Habitat or Water Reservoir are located in a sunny area, a protective covering should be used.

Step 1 (Selecting a Covering)

The material of the covering is not important, as long as it completely shields the water from the sunlight. It may be helpful to select coverings that are of light-weight material, to make adjusting and relocating them easier. Sheets of lumber or metal can be very effective shades, but can also be unnecessarily heavy. Dark cotton sheets, or even standard car windshield sun-shades, can do just as good of a job and are much easier to adjust and relocate.

Step 2 (Installing the Covering)

When adding the protective covering, be sure to check the coverage effectiveness at all times of day, as the sun moves across the sky. The covering may need to be adjusted throughout the day, or multiple coverings may be needed.

If the Aquaponics system is located inside, the shade material may only require minimal attachment. If an outdoor system is being considered, the shade material will need to be attached more securely to account for any breezes or other elements that may displace the material.

Ancillary Components

In addition to the three major components discussed above, there are additional ancillary components needed to support the Aquaponics system. The main component that needs to be addressed is the system filter. The Water Pump and Plant Supports could also be considered Ancillary Components as well.


The system filter plays the key role of filtering out the solid portions of waste from the Fish Habitat that cannot be absorbed or utilized by the Plant System. This filter is one of the few components that will require regular maintenance. A reusable filter is highly recommended.

If one prefers to minimize costs and does not mind the work of a weekly cleaning, a reusable filter is certainly the best option, even with the higher initial cost. If one prefers a more hassle-free solution, disposable filters may be a better option.

The most recommended option for a reusable filter are Matala sheets, also called Matala filters. These can be found at most Fish stores or Pet stores. Matala sheets do a great job of filtering out both large and small particles, while maintaining a smooth water flow through the filter.

Installing and using a Matala sheet as a system filter is very simple. Simply cut a Matala sheet down to the same size as the Water Bed Component, and fit it into the component near the water inlet end, as depicted in Figure 13 below. All plants should be located in the Water Bed beyond the filter.

The filter should be located approximately 6” from the edge of the Water Bed, to allow space for water circulation and filtration but still maximize the plant growth space available.

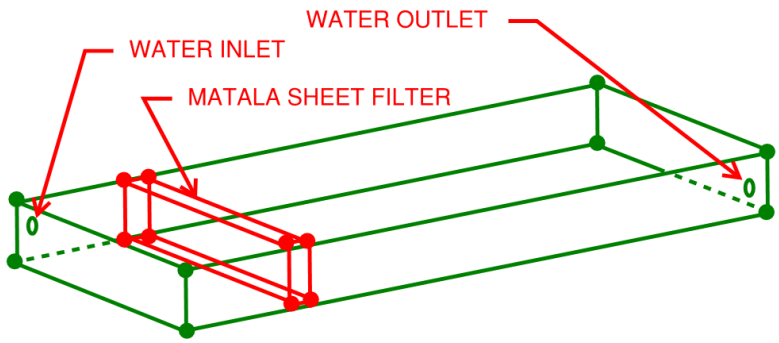


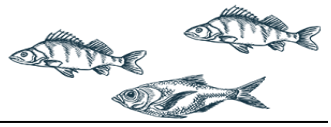
Figure 14: Matala sheet filter installation

If the Matala sheet is cut slightly oversize and wedged firmly into place, it may not require any additional securing. If it is not staying in place, a waterproof adhesive such as duct tape or silicone tape can be used to secure the Matala sheet to the edges of the Water Bed.

The system filter should be cleaned approximately once per week, depending on the environment surrounding one’s specific Aquaponics system. To clean the filter, simply remove the Matala sheet and rinse thoroughly under running water. Do not wash the

filter with soap, as any residue left on the filter will introduce undesired chemicals into the Aquaponics system.

When cleaning the filter, pay attention to what specific foreign objects are being captured. There may be some unexpected things present, such as large leaves or other foreign objects. These may provide information about undesired objects in the surrounding area that are entering the Aquaponics system and need to be addressed.

THE WATER SYSTEM

Water Preparation

It is important to remember that the water in the system is living, just as much as the plants and fish. The Water system needs to be cared for and monitored, just like the Plant system and the Fish system. To start things off right, the water should be fully filtered. Starting with clean water in the empty system, and cycling the system for several minutes, should provide this.

There are four important factors to monitor when considering the Water System. These factors are:

- Oxygen Level
- pH Level (acidity)
- Temperature
- Nitrogen Level

These four factors may sound complicated, but they are actually relatively simple to monitor using basic water test kits. These water test kits are available at any fish/fish tank or swimming pool supplier. If there are issues with any of these factors, some water maintenance may be required. The section below gives detailed information on how to address each of these factors specifically.

Water Maintenance

If an adequately sized pump is selected, there should be some minor disturbances that make their way to the water surface of the Fish Habitat, and there should also be no issues with the Oxygen Level. Some signs that there is not enough oxygen in the water include fish crowding around the pump inlet or outlet, or fish consistently coming above the water surface (outside of feeding time).

The pH level of the water in the Fish Habitat should be between 6 and 7. One simple way to raise the pH level is by adding baking soda. To lower the pH level, consider adding natural components such as pieces of old wood, or some peat moss. When adding components to the Fish Habitat, take care to ensure they remain stabilized at the edge or bottom of the tank. Too much debris floating through the tank inlet/outlet will quickly cause a clog.

The required temperature level will vary depending on the species of fish selected for the Aquaponics system. The water temperature of the system will closely follow the

temperature of the system's surrounding environment. The best way to change the temperature of the water in the system is to change the temperature of the surrounding environment. Since this is often not an option for outdoor systems, it is important to select a fish species that will thrive in the specific climate one's system is located in.

As long as the Plant System is active, healthy, and growing, the nitrogen level of the Water System should be well maintained. The Plant System plays a critical role in the health of the Fish System and overall Aquaponics water systems. It helps regulate the Nitrogen level, and consumes the food provided from the fish waste.

In addition to these four key factors, it is important to monitor the overall environment of the Aquaponics system, with respect to the water system. If a protective cover is used consistently and no additional foreign objects are introduced to the system, the water should stay clean and healthy as it is processed through the system.

However, it is inevitable that at some point the water quality will begin to deteriorate. If caught early enough, some simple maintenance as noted above can bring the water quality back up to a healthy level.

Water System Cycling

It is important to understand how the water moves through each step of the Aquaponics system, and what is happening to the water in each step. The water is the medium that allow the Fish System and Plant System to interact and support each other. Figure 14 below shows a basic schematic of what happens to the water at each stage of the Aquaponics system.

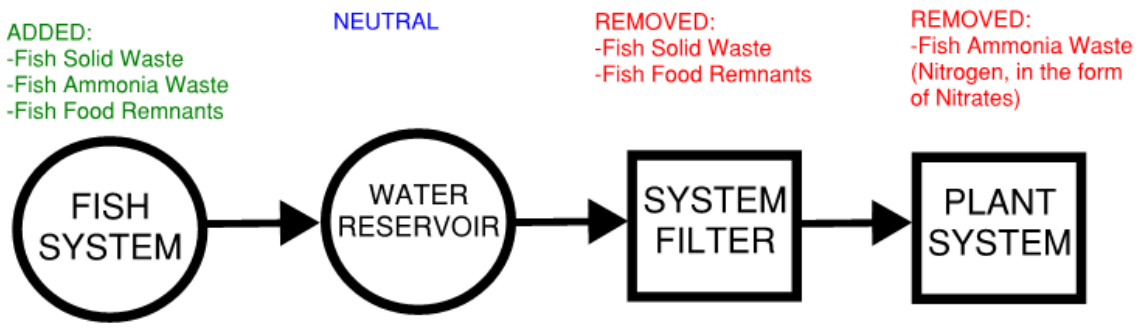
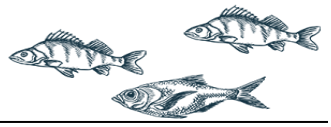


Figure 15: Water System Cycling process



As noted previously in this guide and depicted in the above figure, in the Fish Habitat fish waste is added to the water. This waste-filled water is carried into the water reservoir. As the water leaves the reservoir and passes through the pump into the Plant Water Bed, it continues to carry with it nutrients from the fish waste that will provide food for the plants.

The water passes through the system filter located at the entrance to the Plant System. This filter removes solid waste and debris, as these cannot be absorbed or used as nutrients by the Plant System. The ammonia-filled water then moves on, cycling through the Plant System.

The plants absorb nitrogen in the water through their roots. This is an essential step in lowering the water nitrogen level before it passes back to the Fish Habitat. Once the water has been filtered and cleaned by the Plant System, it passes back to the Fish System for the process to begin again.

The overall Aquaponics system structure should be observed from time to time, to ensure this Water System cycling process is continuing to flow smoothly, and that no clogs or back-ups are present. Undesired changes in system component heights or levels can create serious problems, but these problems are often easily fixed with a slight adjustment to the components.

The Water System is the “life blood” of the entire Aquaponics system, providing the Plant System the nutrients it needs and the Fish System the habitat it needs. If this first system can be started and maintained effectively, one’s Aquaponics system will be well on the road to success.

THE PLANT SYSTEM

Plant Selection

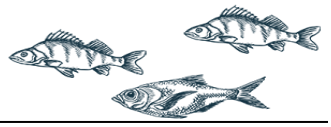
There are a number of factors to consider when beginning the plant selection process. The best starting point is to consider plants that are native to one's local region. If one is building an indoor Aquaponics system, it is possible to consider additional plant options that are not native to the region. However, even with the regulated temperature, there are other factors such as altitude and air quality content that may not be controlled. One should of course also consider what kind of plants they find appetizing or desirable. Most of the plants listed below can be found at one's local greenhouse. Alternatively, these plants could be started from seed outside of the Aquaponics system, and then transferred to the system once they have reached the transplanting stage.

Important factors to consider are rate of growth, amount of sunlight available, and whether the system is indoors our outdoors. There are many different options when selecting the plants for one's specific system, but this guide will discuss 3 general types of plants.

If the goal is to produce as much greenery or content as quickly as possible, Lettuce, Spinach or Watercress are good options. Watercress is the fastest growing but multiplies quickly and may soon overcrowd the Plant Water Bed. One may also tire quickly of eating Watercress. Lettuce or Spinach are good middle-ground options in the fast-growing category.

They will not produce quite as fast as Watercress, but most people find a wider variety of options available when preparing and eating Lettuce or Spinach. With these leafy plants, it is important to keep an eye out for small bugs and insects. They should not attract as many insects as a fruit-bearing plant would, but some bugs can destroy an entire leafy plant very quickly. Caterpillars are an especially infamous culprit to keep an eye out for, especially if the Aquaponics system is located outside.

If the focus is not on producing a quick harvest but rather on producing a quality harvest with fruit, Tomatoes can be a great option. There are many different types of tomato plants, but varieties that produce smaller fruit, such as cherry tomatoes or roma tomatoes, are usually the most successful. Again, one should consider the local region, and select plants that have been proven to do well there. As mentioned previously, it is important to note that any fruit-producing plants, especially tomatoes, will almost certainly attract some insects. This may not be as large of an issue if an outdoor

Aquaponics system is being constructed but should still be considered. If an indoor Aquaponics system is being considered, it may be best to plan for leafy plants only to keep from inviting too many insects into one's home.

Cucumbers can also be very successful growing in an Aquaponics system. These plants are excellent at regulating the nitrogen levels in the water, keeping things clean and healthy for the fish system. Cucumber plants do have large vine-like root systems that can reach to the water inlets/outlets or system filter and clog the system. One should monitor these root systems and trim them as necessary.

It is recommended that for the first life-cycle of one's Aquaponic system, a variety of different plants are selected. This will provide good information on what plants do well in the specific environment and climate present, as well as what plants one particularly enjoys seeing, caring for, harvesting and eating.

Plant Life

The goal of an Aquaponics system is to move the plant through its full individual life cycle as quickly as possible, in order to maximize harvest yield. As noted previously, the time of this life cycle will vary depending on the plant type selected, but it is still desirable to accelerate this process as much as possible.

One key factor to ensuring the plants are growing as fast as possible is maximizing sunlight. Depending on the location of one's specific Aquaponics system, this may occur naturally or steps may need to be taken to ensure this occurs. If an indoor Aquaponics system is selected, or an outdoor system as a somewhat shaded area, supplemental light may need to be provided. Consider adding a small fluorescent light, or a heat lamp if needed for the climate, to help accelerate the Plant System growth. The Fish System should provide enough food for the plants, if sized appropriately. The Water System will of course provide as much water as needed. The sunlight is the only key factor missing that one must take care to ensure is provided in large amounts.

Another important step in accelerating the growth of plants is strategic pruning and harvesting. Depending on the type of plants selected, strategic trimming and pruning should be executed as needed. It is important to make sure the main leaves or fruit-bearing branches are receiving as much of the nutrients as possible, and smaller or dying leaves or fruit-bearing branches are not robbing the plant of nutrients unnecessarily. Regular trimming or pruning is main factor within one's control, and the best thing one can do to accelerate the growth and life cycle of the Plant System.

Plant Support

Depending on the specific Aquaponics system setup, the plants are usually the part of the system that are seen the most. This means that they are also the most obvious to monitor and identify when support is needed. If one notices the plants starting to become wilted or dead, the first step should be to review the surrounding environment. Large changes in temperature, not enough sunlight, or a crowded growing area can all deplete plant health.

Other problems that can develop include plant-eating insects or plant diseases. If one finds that the Plant System is repeatedly struggling with the presence of plant-eating insects, it may be necessary to add a screen cover or netting cover to the Plant Water Bed.

As mentioned previously, all of the plants listed above can be purchased from one's local greenhouse or started from seed if desired. One's local greenhouse should be able to provide region-specific plant care tips and recommendations. If starting plants from seed, start with twice as many plants as needed for the Aquaponics system.

When ready to be transplanted, add 1-1/2 times as many plants to the Aquaponics system as actually needed. Transplants from seedlings are typically more fragile than plants purchased from a local greenhouse, and usually do not all survive. In the first few weeks following the transplant, remove any weak or dead plants as needed so that the appropriate quantity of plants are remaining in the Aquaponics system.

THE FISH SYSTEM

Fish Selection

This may be the most difficult of all the decisions one makes. The life cycle of the Fish system is by far the longest, and so, once selected, the species of fish will be set for the full life cycle of the Aquaponics system. Factors to consider when selecting fish type include

- Growth Time
- Hardiness
- Food Requirements
- Space Required
- Taste

Tilapia is the most common choice for an Aquaponics system. It most easily satisfies all of the criteria listed above. Tilapia are a very hardy fish – they can live in a water system that is anywhere between 60 degrees and 80 degrees. However, if the water temperature drops below 60 this can kill them, so they may not be the best choice for colder or winter climates. Tilapia typically grow the fastest of all the fish options, reaching the harvestable weight of 16 ounces in approximately 6 months. All species of fish considered will require minimal space, as the Aquaponics system typically drives this requirement.

Tilapia fall into this category, as they do well even in a crowded environment. Another advantage to Tilapia is the small amount of fish food required. While there is not a significant variance between fish species, the minimal amount of food required by Tilapia may be desirable if the goal is to keep system maintenance as low-cost as possible. Finally, Tilapia has a fairly mild flavor, and the taste is typically appealing to a wide range of palettes.

Yellow Perch is another species that satisfies all of the criteria listed above. It can do well in slightly cooler water, and also has a fairly short growth time. Yellow Perch typically reach harvestable weight in approximately 9 months. Yellow Perch are a hardy, slightly smaller fish. If one desires a larger quantity of fish in the Aquaponics system, while maintaining the 1 pound per gallon rule, Yellow Perch may be a great choice. Yellow Perch do not require much food – only slightly more than required by Tilapia. They do tend to have a slightly more distinct taste than Tilapia, so that may be important to keep in mind.

Catfish are a less traditional alternative, but still an option. Catfish are extremely hardy and can adapt to a variety of harsh environments and climates.

While they can survive in a wide range of temperatures, they do grow best in warmer water, between 70 and 85 degrees. They do require more food, and must be fed a food that is high-protein. They also have a longer growth time – they take approximately 18 months to reach a harvestable weight. They are also very sensitive to being touched or handled by humans, so a system with minimal maintenance and owner activity would be best. There are some who thoroughly enjoy the taste of Catfish, so that may be a desirable factor to consider.

Goldfish are a very non-traditional option, but worth mentioning. Typically, the dual purpose of the fish in an aquaponics system is to provide food, and to provide nutrients for the plants. If one wishes to provide nutrients for the plants only, and desires to have

fish present but not for harvesting and eating, Goldfish are an option. Goldfish are extremely hardy, and can survive in a variety of environments and climates, including crowded ones. They are also considered by some to be pleasant to look at and have present. If one's desire is to have fish present for plant food only, and never harvest/eat them, Goldfish may be a good option.

All of the fish listed above can often be found at one's local farm store. Alternatively, local Pet Stores or Aquarium Stores may carry some of these species. One's local farm store may also be able to suggest additional fish species that are available and would do well in the specific Aquaponics system environment created. Consult with the local stores, and consider the full range of temperatures and climates present in the Aquaponics system, before making a final fish species selection.

Fish Health

Of the three systems, monitoring the health of the fish can be the easiest. While not the most visible system, they are the most active and observable. There are a few key indicators that can be used to determine what, if any, changes are needed.

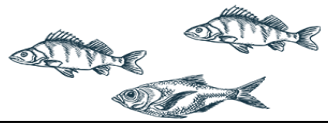
The main contributing factor to the fish health will always be the water quality. "The Water System" section of this guide gives detailed information and instructions on maintaining the water quality. Another significant factor that will contribute to the fish health is the food. It is important to keep the food type consistent, once a good food type has been identified. While it is tempting to select the cheapest fish food available, higher quality fish food is often worth the investment. Higher quality fish food typically contains more fiber and protein, which is very important.

One major thing to monitor for the Fish System is the fish activity. It is normal for the fish to move slowly outside of feeding time. But if they stop swimming altogether, are slow-moving during feedings, or are not eating at all, these are warning signs that the fish are not healthy. Ultimately, the best thing you can do for the Fish System to increase and maintain the health of the fish is to manage the stress. From water temperatures to climate changes to food types, fish thrive the most in a stable environment that is free from the stress of constant changes.

Fish Life Cycle

The fish life cycle will almost always be the controlling and limiting factor in an Aquaponics system. There are some who are proponents of Hydroponics over Aquaponics for this reason alone. However, while the fish life cycle is the longest, there are still steps that can be taken to accelerate this. As mentioned previously, the type of fish food used and the frequency of feedings plays a key role, as does the overall fish health. Ultimately, the best way to optimize fish growth and growth speed is to maintain the fish health by following the guidelines given in the previous section. Following these guidelines, ensuring the Fish Habitat is not overcrowded, and selecting a fish species with a short growth time are the key steps to having fish that are a harvestable weight as soon as possible.

It is recommended that all fish be harvested at the same time, or in a short of a time period as possible. It is not recommended to mix mature or near-mature fish with new young fish, as there is a high probability of the new young fish being eaten by the mature fish. The new batch of young fish should be added all together at the same time, into a system that has had two to three days to stabilizing after the deep cleaning.

STARTING THE SYSTEM

The First Week

It is important to monitor the new Aquaponic system closely during the first week. Ultimately, the goal is to have an Aquaponic system that is self-sustaining and requires minimal monitoring and upkeep. In order to develop a system that meets this goal, some adjustments during the first week may be required. Key things to monitor include

- Water Level and Cleanliness
- Filter Status
- Fish System Activity
- Plant System Health

If the water level in the water reservoir is consistently decreasing, double check all hose connection points to ensure there are no leaks present in the system. Add water as needed to maintain a full reservoir but try to determine what is causing the loss of water. A small decrease is expected, due to evaporation, but large amounts of water loss may indicate a leak.

If algae are accumulating on top of the water in either the Fish Habitat or the Water Reservoir, too much sun is reaching the water surface. Consider adding additional covering or taking other steps to ensure both water sources are completely in the shade. Too much algae will decrease the quality of the Fish Habitat environment and will also clog the filter in place unnecessarily.

The filter should be cleaned approximately once a week. It may need cleaned more often initially, when first starting up the system. After the first week, if the filter is becoming full and clogged after only a day or two, look into the environment surrounding the Aquaponics system to ensure no foreign materials are entering the system. Leaves, grass, dirt, and even dust can easily find their way into the system and quickly clog up the system filter. The filter is mainly intended to filter out only the contents present in the closed-loop Aquaponics system.

When feeding the fish during the first week, check and make sure there is healthy activity. It is important to make sure the fish are adjusting well to the new environment. It is not concerning if there is not much movement from the fish throughout the day, but there should be a healthy amount of activity during feedings.

The Plant System health will be the most obvious when monitor during the first week, as it is the most visible. It is important to ensure water is reaching the roots of all plants present in the system. As noted in the "Plant System" section , some minor trimming of smaller or wilting leaves may also be required, in addition to the regular main harvest.

The First Harvest

For many people, the most exciting part of owning an Aquaponics system is the harvest. Becoming familiar with one's specific system, and when and how each harvest should occur, is something that will take both time and experience.

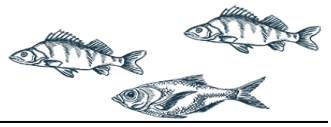
For the Plant System, it is important not to wait too long to harvest and trim. Allowing the plants to grow too large can create many problems including overcrowding, lack of nutrients, and even going to seed.

However, harvesting too early can result in damaging the health of the plants, or missing out on the largest or most efficient stage of growth and development. 6 weeks per harvest is a good starting point for the plant system, but this should be adjusted to accommodate the plant types present in one's specific system. After the first few harvests, a familiarity with the life of both the Plant System and the whole Aquaponics system will develop.

For the Fish System, the harvest will not occur as frequently. The fish system harvest schedule will be the determining factor for the complete life cycle time of the Aquaponics system. Determining the appropriate harvest time will depend mostly on the optimal growth stages. If the purpose of the Aquaponics system is to generate as much food and sustenance as possible, the fish should be harvested as soon as either the growth begins to slow or the fish reach an acceptable harvest size – whichever occurs **last.** Similar to the plant system, after the first few harvests a familiarity should develop with the life of the Fish System.

One should not be discouraged if the first or even the second harvest are smaller than expected. Even the most experienced growers typically see a slightly reduced harvest following the first cycle. It takes time, first for one to become familiarized with the specific Aquaponics system, and second for the system to develop and the climate of each system to stabilize.

During the first few harvests of both the Plant System and the Fish System, it may be helpful to note dates, quantities, and conditions. Having a record to refer back to can come in very handy when planning for future life-cycles. One can make more informed decisions and plans about a specific Aquaponics system if there is information readily available regarding past harvest dates, quantities, and conditions.

The First Deep-Clean

Upon completion of the first complete life cycle of the Aquaponics system, a thorough deep-clean of the entire structure should be carried out before adding new fish and additional plants. The Flood Table and the Plant Supports should be removed and cleaned individually. Plant Support components may need to be repaired or replaced, if the structural integrity is becoming compromised.

The Fish Habitat should be thoroughly scrubbed, especially around the inlets and outlets. The water reservoir may not require too much cleaning, but the water pump should be thoroughly wiped down and dusted. If an inline pump has been selected, as recommended, take care not to spill too much water on the pump when cleaning each component.

Finally, the surrounding area should be cleaned as needed, and any loose debris should be removed. Although it has already been mentioned previously, it cannot be emphasized enough how important it is to keep the surrounding environment of an Aquaponics system clean. The concept of a healthy closed-loop system fails when anything from outside the system is added.

During this process, it is important to make sure the water pump is not run without water in the system, as this will damage the pump. If any soap or chemical cleaners are used, ensure all components are thoroughly rinsed and dried. Any soap or cleaner residue remaining that makes its way into the system can be very damaging to the health of both the fish life and plant life. The main goal of the cleaning process is to remove all algae and debris present and allow the Aquaponics system time to cycle water through all the components thoroughly.

Following any deep clean, the system should always be given two to three days to stabilize before adding new fish to the Fish System. Plants can be added immediately once the system is up and running again, but it is important to add the fish last, and only after two to three days. Almost all fish species are highly prone to shock, and the greatest chance of this occurring is always when they are being introduced to a new environment.

MAINTAINING THE SYSTEM

Common Issues

In an ideal scenario, the entire Aquaponics system would be constructed, setup, and started with no problems or issues along the way. Realistically, there are a number of minor common issues that may develop. A few of the most common issues include:

- Leaky Hose Connections
- Water Pump Failure
- Clogged Filter
- Struggling Plant Health
- Struggling Fish Health

If there is an opportunity for a leak, running water will always find it. In this Aquaponics system, the greatest opportunity for leaks is in the hose connections. If a leaky connection is identified, ensure the Uniseal fitting is fitted tightly, and the seal is free of debris or obstructions. Remove and reattach the connection if needed. In some cases, a completely new fitting may need to be installed.

If the water pump is not operating as expected, check to ensure that water is flowing through the system correctly while the pump is turned off. Refer to Figure 1, Figure 8, and the "THE STRUCTURE" section of this guide as needed.

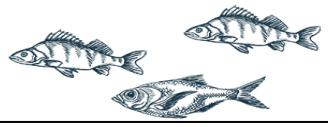
Back-up of water flow can put an unnecessary load on the water pump, restricting its ability. If the system is setup for proper water flow, double check the filter to ensure no large clogs or blockage of water are present. Clean or replace the filter, if necessary.

If the plant health is struggling, check to make sure the plants are receiving enough sunlight throughout the day. It is also important to make sure that the plants are not exposed to a large swing in temperature or climate. Make sure all plants are receiving adequate water, but no plants are overly submerged.

If the fish health is struggling, check the instructions on the fish food being used to ensure the fish are not being over-fed or under-fed. It is also helpful take a sample of water from the fish habitat and inspect it, to see if debris or excessive algae are present.

Preventative Maintenance

There are a few steps that can be taken to ensure larger issues do not develop in the future.



The hose connections should be replaced approximately once a year, or once every 2 - 3 cleanings, whichever comes first.

The Water Pump should be removed from the system and cycled with clean and purified water approximately once every 3 months.

The temperature and climate of the overall Aquaponics system should be monitored, and steps should be taken as necessary to prevent overly large changes. Both the plant life and fish life depend on a stable and consistent environment.

The Plant System should be closely monitored for any damaging insects, and if found these should be removed immediately. This is especially important if leafy plants are selected.

CONCLUSION

In the introduction of this guide, it was recommended that one read through this text in its entirety before beginning construction of an Aquaponics system. After reading through this guide, there are a few main concepts that should come to mind.

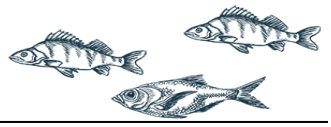
First, the overall Supporting Structure of the Aquaponics system is comprised of 3 main components (Fish Habitat, Plant Water Bed, and Water Reservoir). These components can be items one already has available, one purchases pre-made, or one constructs to a custom size and shape.

There are of course additional ancillary components needed, and there are more specific details for each of these 3 components. But these 3 main components will drive the overall size and setup of one's specific Aquaponics system. There is flexibility in what each component is made from, and room for creativity. As long as each component serves the specific functions given above in this guide, it can be successfully incorporated into one's specific Aquaponics system setup.

Second, each individual system in the overall Aquaponics system (Fish System, Plant System, and Water System) should be developed and monitored both individually and in connection with all systems. For each system, there are specific items to look for when monitoring the health and development, but there are also general concepts to consider for the Aquaponics system as a whole. In the early stages and throughout the entire life of one's Aquaponics system, it is important to keep this information in mind.

Third and finally, the life of one's specific Aquaponics system, and that life's health and growth, will depend significantly on the local climate and environment. Whether the system is large or small, located indoors or outdoors, in a mild climate or fluctuating climate – these factors will all play a role in determining the overall resulting system, and ultimately, the harvests.

The final result of one's Aquaponics system should not be compared to other systems, but rather to the desired outcome of one's specific system. The goal is not to create an Aquaponics system that is mostly generic. The goal is to create an Aquaponics system that will fit one's specific space and environment available, and will meet one's specific desires. The directions and instructions given in this guide are not to ensure that all Aquaponics systems constructed end up similar overall. They are given to ensure that one's specific setup becomes a successful and thriving system.

Keeping these three main concepts in mind throughout the process will help keep things on track. After reading through this guide, take some time to envision the specific Aquaponics system desired, based on the available location, environment, and components. Take some notes and sketch up a rough layout. Then skim through this guide again to ensure that the key directions and instructions given can be implemented in the Aquaponics system being planned. If this is the first time one is constructing an Aquaponics system, there will undoubtedly be minor undesired surprises and hiccups that develop. Be sure to read through the "Common Issues" and "Preventative Maintenance" sections thoroughly, to anticipate these items and be prepared with solutions.

Owning an Aquaponics system does require an initial investment, but it can be a very rewarding experience. There is nothing like the feeling of sitting down to a meal made completely from plants and fish grown and harvested from one's very own Aquaponics system. This guide was written with the goal of providing directions and instructions for achieving that rewarding and sustainable experience.